EXHIBIT 77

Declaration of J. Christopher Clemens

IN THE UNITED STATES DISTRICT COURT
FOR THE MIDDLE DISTRICT OF NORTH CAROLINA
CASE NO. 1:14-CV-954

STUDENTS FOR FAIR ADMISSIONS, INC., **Plaintiff,** **v.** **UNIVERSITY OF NORTH CAROLINA et al.,** **Defendants.**	

DECLARATION OF J. CHRISTOPHER CLEMENS

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I, J. Christopher Clemens, hereby make this declaration from my personal knowledge and, if called to testify to these facts, could and would do so competently:

Experience

1. I am currently Senior Associate Dean for Natural Sciences and Professor in the Department of Physics and Astronomy at The University of North Carolina at Chapel Hill ("UNC-Chapel Hill").

2. I am an astrophysicist who received my Bachelor's degree in Astrophysics from the University of Oklahoma. I received my Ph.D. in Astronomy from the University of Texas at Austin.

3. After graduation, I completed two fellowships. The first was as a NASA Hubble Fellow with Iowa State University. My second was as a Sherman Fairchild Postdoctoral Fellow with the California Institute of Technology ("Caltech"). After my fellowships, I joined UNC-Chapel Hill in 1998.

4. My research studies compact remnants known as white dwarf stars, the objects that form when ordinary stars like our sun run out of fuel and shrink to the size of the Earth. My recent projects include seismology of oscillating white dwarf stars and the study of exoplanetary rubble that forms around white dwarfs when asteroids, comets, or planets are broken up by high gravity. I also build spectrographs and spectrograph components for observatories around the world.

5. I have authored or co-authored more than 100 research papers. I also hold four patents and am principal investigator of two major National Science Foundation grants. I have been recognized with the Hettleman Prize for Artistic and Scholarly Achievement and the Faculty Award for Excellence in Doctoral Mentoring.

6. I am also an entrepreneur who has co-founded two startup companies. The first of these, MegaWatt Solar, Inc., developed concentrating photovoltaic technology. I served as Chief Technical Officer of MegaWatt Solar, Inc., from 2007 to 2009. The second company, Syzygy Optics, LLC, develops large diffraction gratings for astronomical instruments.

7. I helped to start UNC-Chapel Hill's Institute for Cosmology, Subatomic Matter & Symmetries ("CoSMS Institute"), in partnership with North Carolina State University, Duke University, and Oak Ridge National Laboratory. The CoSMS Institute brings together scientists interested in the topics of cosmology and astrophysics, subatomic matter, and fundamental symmetries. The idea behind the CoSMS Institute is to promote stronger interactions between scientists working in a diverse range of research areas in fundamental physics— from theorists to experimentalists to computational scientists – and to make better progress by collaborating more strongly. We hope that The CoSMS Institute will lay the groundwork in fundamental physics and astronomy, not just for the next 10 years at UNC-Chapel Hill, but for the next 50 years, the next 100 years. A direct benefit of this research is that we are training the next generation of citizens and scientists to compete in a global technological economy.

8. In my current role at UNC-Chapel Hill, I oversee the departments/curricula in: applied physical sciences, biology, biomedical engineering, chemistry, computer science, environment and ecology, exercise and sport science, geological sciences, marine sciences, mathematical decision sciences, mathematics, physics and astronomy, psychology and neuroscience, and statistics and operations research, as well as the Chancellors Science Scholars program. Before becoming Senior Associate Dean, I served as Chair of the Department of Physics and Astronomy at UNC-Chapel Hill for four years.

9. I have taught both introductory and upper level astronomy courses in the Department of Astronomy and Physics. In addition, I am a faculty member of the Program in Medieval and Early Modern Studies, for which I designed and taught the course "Medieval Foundations of Modern Cosmology."

10. I am a Christian and frequently make public presentations on the topic of faith and science, most recently at the 2017 Society of Catholic Scientists conference called "Origins".

11. I was born in Pascagoula, Mississippi and lived there 17 years.

12. I am registered to vote as a Republican.

13. I am a White male.

14. Clemens Decl. Ex. 1 is a true and correct copy of my CV. Clemens Decl. Ex. 2 is a true and correct photograph of me from my UNC webpage.

Diversity in the Sciences at UNC-Chapel Hill

15. Underrepresentation of women and minorities in physics is a major issue. Both groups are poorly represented in my field.

16. In the sciences, and in the context of our graduate school admissions, we are aware of research that shows that women and minorities can be disadvantaged by implicit biases concerning their roles and abilities. Implicit bias refers to the attitudes or stereotypes that affect our understanding, actions, and decisions in an unconscious manner. These biases, which encompass both favorable and unfavorable assessments, are activated involuntarily and without an individual's awareness or intentional control.

17. For instance, Corrine Moss-Racusin, a social psychologist at Skidmore College, conducted research on gender bias among science, technology, engineering, and math ("STEM") faculty, including an experiment that had scientists evaluate identical resumes of a candidate named either "Jennifer" or "John." In the experiment, despite having the exact same qualifications and experiences as John, Jennifer was perceived as significantly less competent. As a result, Jenifer experienced a number of disadvantages that would have hindered her career advancement had she been a real applicant. Because scientists perceived the female candidate as less competent, they were less willing to mentor Jennifer or to hire her as a lab manager. They also recommended paying her a lower salary.

18. Similar studies have been done concerning race and ethnicity.

19. As a result of this research, we are committed to acknowledging our implicit biases and attempting to minimize their impact.

20. We also know that there are barriers to women and minorities remaining in the sciences, including the challenge for these students of being a small minority without sufficient role models, peer support, or mentors who understand the challenges they face. It is difficult to attract diverse students to the sciences and to help them succeed in their chosen fields if they do not believe they belong.

21. Another barrier is cultural. Physics is a hypercompetitive field that attracts driven, aggressive, outspoken, and inquisitive students. This environment can be intimidating for students who feel like "outsiders." I have observed women, for example, who have felt sidelined by the culture in the laboratory and the classroom.

22. I believe that talent for science does not know bounds of gender, socioeconomic status, race, religion, or national origin. Our job is to train the next generation of talented scientists. We will lose talented scientists if we allow implicit biases and other barriers to prevent women and minority students from entering the sciences, or if we fail to support their careers when they do.

23. We know the talent for science exists in diverse groups of students, and we need to do a better job of bringing that talent into our programs. If we do not do that, we will deprive the world, our field, UNC-Chapel Hill and UNC-Chapel Hill's students of a large talent pool. We will never hear the ideas and new ways of thinking these students have to offer.

24. Having a good pipeline of diverse undergraduates from top programs will be essential to increasing the number of diverse scientists in graduate school and in the field. Decreasing the existing gender, ethnic, and socio-economic disparities in the sciences will help us to attract even more diverse scientists and benefit from their ideas and talents.

25. Diversity also improves understanding and capability of our students given the importance of peer instruction in the sciences. The best test of whether you understand a concept is whether you can teach it to someone else, so peer teaching and learning is fundamental to our pedagogical efforts. Teaching and learning between diverse peers, which requires explaining things to people with different backgrounds or who may think or learn differently, helps our students understand things better. Research about education in our field shows that peer education is among the most effective ways for our students to learn.

26. Like other introductory science courses at UNC-Chapel Hill, our introductory physics courses are now structured to promote interactions between students in which they can learn from one another. For our entry level courses, we use a lecture studio model. Two hours per week are taught as a lecture and two-to-four additional hours are completed in the studio. In that setting, groups of three-to-nine students have to perform experiments or exercises at their table and answer a problem set together. There are instructors circulating in the room. These courses are structured and interactive, and

they offer a great way for our students to truly learn the material and teach one another. Diversity significantly contributes to our students' educational experience in this model.

Chancellors Science Scholars

27. As noted above, I supervise the Chancellors Science Scholars program, which began as a partnership in 2011 with the University of Maryland Baltimore County ("UMBC")'s nationally recognized Meyerhoff Scholars program and the Howard Hughes Medical Institute. The purpose of these relationships was to diversify and provide access to jobs in the fields of STEM.

28. As an organization, the Chancellor Science Scholars work to bring awareness to the issues of diversity as well as provide a program where students, regardless of background, can be supported to pursue fields in STEM.

29. We seek to maximize student success by building a community of learners who work collaboratively to succeed academically and in research. Our cohorts provide our students with a community of peers from diverse backgrounds. The cohorts provide an environment where these students can challenge each other to think differently and ask questions that foster intellectual growth.

30. We also open doors for students to experience research within and outside of UNC-Chapel Hill, allowing them to be an active part of the teams of scientists addressing some of our most fundamental scientific questions.

31. Mentoring is a key component of the program. We help our scholars develop a mentoring circle to support their academic and career goals.

32. We are preparing our scholars to move into Ph.D. and M.D./Ph.D programs after graduation and to become part of the next generation of leaders in science and technology.

33. Clemens Decl. Exhibit 3 contains photographs accurately depicting various groups of Chancellor's Science Scholars at UNC-Chapel Hill. Photographs and information about the program can also be found at http://chancellorsssciencescholars.web.unc.edu/.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on 8/7/2017.

J. Christopher Clemens

Exhibit 1 to Clemens Declaration

CURRICULUM VITAE: J. Christopher Clemens

Personal

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Phone:	919-962-2079 E-mail: clemens@physics.unc.edu

Education

Ph. D., Astronomy	University of Texas at Austin, 1994
B. S., Astrophysics	University of Oklahoma, 1985

Professional Experience

2016-current	**Senior Associate Dean of Natural Sciences and Mathematics**
2016-current	**Jaroslav Folda Distinguished Professor of Physics and Astronomy**
2012- 2016	**Chair, Department of Physics and Astronomy**
2008- 2016	**Professor**
2003 - 2008	**Associate Professor**
1998 - 2003	**Assistant Professor** Department of Physics and Astronomy, University of North Carolina
1996 - 1998	**Sherman Fairchild Postdoctoral Fellow** Astronomy Department, California Institute of Technology
1993 - 1996	**Hubble Fellow** Department of Physics and Astronomy, Iowa State University
1985 - 1993	**Teaching and Research Assistant** Department of Astronomy, University of Texas
1985	**National Radio Astronomy Observatory Summer Student** NRAO, Charlottesville, Virginia

Honors

2012	**Faculty Award for Excellence in Doctoral Mentoring** University of North Carolina, Chapel Hill
2005	**Hettleman Prize for Artistic and Scholarly Achievement** University of North Carolina, Chapel Hill
2000	**Sloan Research Fellowship** Alfred P. Sloan Foundation
2000-2005	**Faculty Early Career Development (CAREER) Award** National Science Foundation
1996	**Sherman Fairchild Prize Postdoctoral Scholar** California Institute of Technology
1995	**Distinguished Dissertation Award in Mathematical and Physical Sciences and Engineering** U.S. Council of Graduate Schools
1993 - 1996	**NASA Hubble Space Telescope Postdoctoral Fellowship**
1985	**Carl Albert Award**

University of Oklahoma College of Arts and Sciences

1985 **Phi Beta Kappa**

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NASA/ADS Metrics Summary

Papers		Total	Refereed
Number of papers	[?]	131	82
Normalized paper count	[?]	34.7	20.1
Total reads	[?]	33,950	31,257
Average reads	[?]	259.2	381.2
Median reads	[?]	189.0	339.0
Total downloads	[?]	16,686	15,934
Average downloads	[?]	127.4	194.3
Median downloads	[?]	82.0	174.0

Citations		Total	Refereed
Number of citing papers	[?]	1,522	1,458
Total citations	[?]	2,842	2,744
Average citations	[?]	21.7	33.5
Median citations	[?]	5.0	21.5
Normalized citations	[?]	406.2	381.8
Refereed citations	[?]	2,314	2,241
Average refereed citations	[?]	17.7	27.3
Median refereed citations	[?]	5.0	18.0
Normalized refereed citations	[?]	342.4	323.9

Indices		Total	Refereed
h-index	[?]	31	31
g-index	[?]	51	50
e-index	[?]	34.7	34.1
i10-index	[?]	57	56
tori index	[?]	16.6	16.0
riq index	[?]	140	137
m-index	[?]	1.07	1.07

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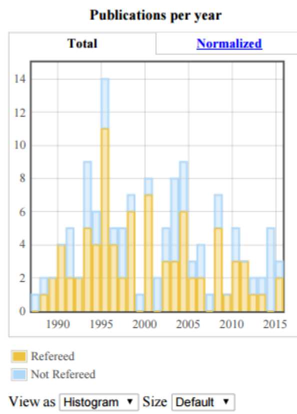

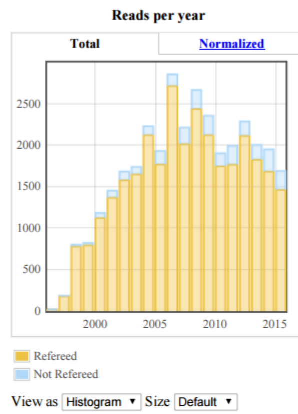

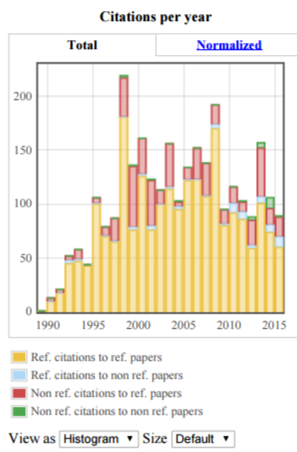

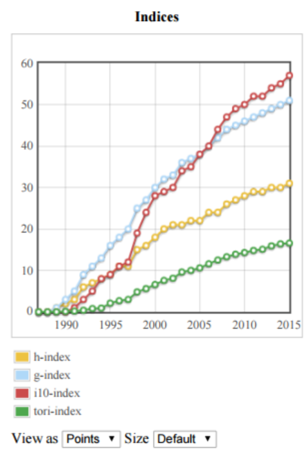

Teaching activities

Courses taught

ASTR 101: Introductory astronomy
ASTR 501 and 701: Stellar Astrophysics (undergraduate and graduate)
ASTR 519 and 719: Observational Astronomy
ASTR 205: Medieval Foundations of Modern Cosmology

Courses developed

ASTR 205: The Medieval Foundations of Modern Cosmology

This is a course in the UNC cluster called:
Knowledge at the Crossroads: Religious and Scientific Cultures of the Middle Ages and the Renaissance

This cluster examines the intersections and conflicts among religious and scientific beliefs, institutions, and practices from around 1300 until 1750. During this period of extraordinary intellectual ferment, writers

and thinkers in various disciplines actively and variously reconfigured the relationship between faith and reason, between scripture and nature, and between religious belief and "scientific" knowledge. Courses in this cluster will expose you to the historical dimensions of questions and conflicts still current in academia and the culture at large: the origins of religious tolerance and pluralism; the potential for conflict (or reconciliation) between reason and faith and between secular and sacred authority. The cluster also offers you an excellent venue for improving your critical thinking and writing by exposing you to cultures and texts that persistently renegotiate competing knowledge claims and ways of knowing.

The ASTR 205 course examines science as it emerged and developed in the West starting in the 13th century. As examples we consider three problems that remain relevant to modern science: the mechanics of celestial bodies, the finite age of the universe, and the nature of the void. Historically, the course is organized around the thesis of Pierre Duhem who proposed that the fulcrum for understanding the emergence of science lies in the mid-13th Century, when problems arose in reconciling the works of Aristotle with dogmas of the Catholic faith. The eventual condemnation of problematic Aristotelian notions legitimized the idea that Aristotle could be wrong, even when no flaw could be found in his reasoning, and stimulated new research and new ways of thinking about problems. Upon completion of the course, students are able to evaluate this thesis critically.

Scientifically, the course traces the development of mechanics starting with Euclid, Aristotle, Thomas Bradwardine (1290-1349), John Buridan (1300-1360), Nicole Oresme (1323-1382), and extending to the modern principles of Galileo, Newton, and Einstein. We consider the observational evidence that was used to overturn each successive theory and the observational challenges to our current understanding. Second, we consider the proposition that the universe is eternal, starting with Aristotle's conviction that it must be, Arguments by St. Bonadventure and John Philoponus to the contrary, Newton and Einstein's return to eternal models, and Fr. Georges Lemaitre's expanding models. We explore the observational evidence for a Universe of finite age, starting with V. M. Slipher and E. Hubble and concluding with the latest results from the Wilson Microwave Anisotropy Probe and the Planck Satellite. Finally we consider the nature of the void, beginning with Aristotle's denial that a void can exist, and ending with contemporary questions about vacuum energy and dark matter in the universe. Upon completion of the course, students have an up-to-date conceptual grasp of modern cosmology.

Mentoring activities

Postdoctoral Fellows Supervised

2015 Bart Dunlap, SOAR Instrument Postdoc
2015 J.J. Hermes, NASA Hubble Fellow (begins Fall 2015)

Graduate students supervised (as major supervisor and committee chair)

current Josh Fuchs, Erik Dennihy

completed
2015 Bart Dunlap (Phd, now SOAR Instrument Postdoc)
2013 Amy Colon (NSF Fellow, Master's Degree, working in industry)
2011 Brad Barlow (PhD, faculty at High Point University)
2009 Jane Moran (PhD, Royster Fellow, working in industry)
2007 Rachel Rosen (PhD, Royster Fellow, working for NRAO, ALMA)
2006 Celeste Yeates (PhD, Royster Fellow, homemaking with 5 children)
2004 Susan Thompson (PhD, working for NASA Kepler Mission)

2004	Mercedes Lopez-Morales (PhD, Royster Fellow, Carnegie Fellow, Hubble Fellow, now at CFA)

PhD committee service (since 2008)

current — Robert Judith (Biophysics), Tommy Osburn (Gravitational Physics), Kris Vorren (Nuclear Physics), Brian Pohl (Astronomy), Lori Downen (Nuclear Astrophysics), Erik Forseth (Gravitational Physics)

completed	2013	Courtney Hadsell (PhD, Condensed Matter Physics)
	2013	Yingchi Liu (PhD, Condensed Matter Physics)
	2012	John Houser (PhD, Biophysics)
	2012	Roseanne Cheng (PhD, Gravitational Physics)
	2011	Seth Hopper (PhD, Gravitational Physics)
	2011	Bayard Stringer (PhD, Astrophysics)
	2011	Nathan Hudson (PhD, Biophysics)
	2011	Adam Trotter (PhD, Astrophysics)
	2009	Leslie Prochaska (PhD, Astrophysics)
	2008	Ben Evans (PhD, Biophysics)

Research grants

Alfred P. Sloan Foundation Grant (BR-3962): $40,000, 2000-2004

Principal Investigator, NSF CAREER : Tools for Training Students in Astronomical Instrumentation and Research: $488,219**,** 2001-2006

Principal Investigator, NSF Advanced Technology Instrumentation: An Advanced Technology Optical Spectrograph for the Southern Astrophysical Research Telescope (SOAR): $226,541, 2001-2003

Co-investigator, US Air Force Supplement to F29601-98-1-0032: $2,070,000 ($765,000 for instrumentation) The Southern Observatory for Astronomical Research, 2000-2002

Co-Principal Investigator, NSF Major Research Instrumentation: Acquisition of PROMPT: Gamma Ray Bursts as Probes: $515,198, 2004-2008

Co-Principal Investigator, NSF PREST: Prompt Phase II: Gamma Ray Bursts as Probes: $176,158, 2004-2005

Principal Investigator, NSF Stars and Stellar Systems: Asteroseismological Investigations of Compact Objects: $520,088, 2007-2011

Principal Investigator, NSF Stars and Stellar Systems: Physics, Cosmology, and Exoplanetary Science with the White Dwarf Stars: $462,787, 2014-2017

Principal Investigator, NSF Advanced Technologies for Instrumentation: Spherical VPH Gratings for Enhanced Spectrograph Design: $132,140, 2014-2015

Professional service

2012-current	**Chair**	
	UNC Department of Physics and Astronomy	
2007-2009	**Member, Board of Directors**	
	MegaWatt Solar, Inc.	
2002-current	**Member, Board of Directors**	
	Southern African Large Telescope	
2012-current	**Member, Board of Directors**	
	Southern Astrophysical Research Telescope, Chile	

Conference and workshop organization

October, 1999	**International Workshop on VPH Gratings in Astronomy I** Head, Local Organizing Committee
October, 2000	**International Workshop on VPH Gratings in Astronomy II** Head, Local Organizing Committee
May, 2014	**SOAR Science Workshop** Head, Local Organizing Committee
September, 2014	**50 Years at the Forefront of Astronomical Instrumentation Design: A Meeting in Honor of Professor Harland W. Epps** Member, Scientific Organizing Committee

Research statement

I have authored or co-authored over 100 research papers (and four patents). There are fifteen or so papers that contain the work I consider most significant, and I review each briefly below. The unifying themes are stellar astrophysics and astronomical instrumentation, but the subfield changes every few years as the problems or questions driving the research are resolved and new ones attract my attention

1. Clemens, et al., 1992, **Whole Earth Observations of V471 Tauri: The Nature of The White Dwarf Variations**, ApJ, 391, 773-783.

V471 Tauri is an eclipsing K dwarf-white dwarf binary in which the white dwarf shows rapid variations. It was my hope that these represented a non-radial oscillation of the white dwarf, from which we could derive basic physics that would illuminate the nature of the white dwarf and its interactions with the secondary star. To decide whether pulsations were present required comparing the phase of the white dwarf variations at high energy (X-ray) to their phase in optical light. This would seem impossible to accomplish without an X-ray telescope, but I

figured out a way to do it using radiation that was reprocessed by the chromosphere of the K-star, essentially using that star as my X-ray detector. This had never been done before, and maybe it has never been done since.

Shortly thereafter, the ROSAT X-ray telescope confirmed my conclusion; the variations were not pulsations, and therefore not interesting to me (though others continue to study them for their own reasons). The observations I made for this project required the construction of two new tools: a small electronic interface for conducting high speed photometry using a PC, and a large network of telescopes spanning the globe. I built the first of these in my first year of graduate school and helped organize the second with Ed Nather and Don Winget at the University of Texas.

2. Clemens, J.C., 1994**, The Origin and Evolution of the White Dwarf Stars**, Ph.D. Thesis, University of Texas, 151 pages.

3. Clemens, J.C., 1993, **The Pulsation Properties of the DA White Dwarf Variables**, Baltic Astronomy, 2, 407-434.

When I began to apply the new equipment and the network of telescopes (called the Whole Earth Telescope) to the study of pulsating hydrogen-atmosphere white dwarfs, a pattern emerged from their eigenperiods. Before this time our ignorance of the eigennumbers associated with each eigenperiod had made it impossible to conduct reliable asteroseismology of individual objects, but now the collective pattern allowed me to make a statistical identification of the eigenmodes and move the field forward. I used this discovery to resolve to my satisfaction a question about the origin of the two major classes of white dwarf stars, the hydrogen atmosphere DA stars, and the Helium atmosphere DB stars. They differ at birth, and cannot readily change their spectral types as they evolve.

4. Clemens, et al, 1998**, The Lower Main Sequence and the Orbital Period Distribution of Cataclysmic Variable Stars**, ApJ, 496, 352-363.

This paper represented a complete change of field for me, and was motivated by a curious coincidence. One of the grasping, early explanations for the solar neutrino deficit was that a phase change occurred in the core of the sun, causing a demixing of hydrogen and iron. Careful calculation of the phase diagram by Iyetomi and Ichimaru showed that the sun is too hot in its core for this to happen, by about a factor of three. However, it is also correct to regard this as a prediction that the phase transition will occur in the core of a 0.3 solar mass star, which has similar pressure but lower temperature than the sun in its core. While I was explaining this to Neill Reid at Caltech, he pulled out a color-magnitude diagram of the lower main sequence from Keck telescope observations that showed an anomalous drop in brightness at about the right mass.

In the course of tracking this down, I proposed that the best experiment one could do to test for the phase transition would be to slowly disassemble a star until it reached 0.3 solar masses and then see what happened to its radius. More astonishing, I realized that this experiment was being performed naturally in hundreds of interacting binary systems known as cataclysmic variables. The main sequence stars in these binaries are slowly eaten by a white dwarf companion star. Moreover, there is an anomaly in the orbital period distribution of these binaries that corresponds exactly to the anomaly Neill Reid had shown me. This paper is an observational and theoretical exploration of the connection between the mass-radius relation of the lower main sequence and the orbital period evolution of cataclysmic variables. It offers an explanation for the well-known period gap in cataclysmic variables, and predicts that better direct measurements of the mass-radius relation for low mass stars will show a

rapid drop near 0.3 solar masses. Although the field at large has not adopted the explanation I recommended, it has been a productive contribution.

5. Van Kerkwijk, M.H., Clemens, J.C.,and Wu, Y., 2000, **Time Series Spectroscopy of G29-38 with the Keck Low Resolution Imaging Spectrograph**, M.N.R.A.S., 314, 209-219.

6. Clemens, J.C., Van Kerkwijk, M.H.,and Wu, Y., 2000, **Line Profile Variations of the ZZ Ceti star G29-38**, M.N.R.A.S., 314, 220-228.

These companion papers grew out of time-resolved spectroscopic measurements of pulsating white dwarfs using the 10 m Keck II telescope, which was undersubscribed during bright time when I was at Caltech. During an observing run allocated to faint sources, we used the part of the night before moon-set to measure (for the first time) the surface motions of a bright pulsating white dwarf. These measurements not only confirmed the statistical eigennumber identifications made some years before, but launched a systematic program to observe line profile variations in white dwarfs. My colleague Marten van Kerkwijk and I both advised graduate students who continued and extended this work.

Our observations also dovetailed with theoretical efforts to understand white dwarf pulsations by Peter Goldreich and his student Yanqin Wu. However, the subsequent discovery of interactions between the surface motions in the pulsation modes of the star G29-38 by my student Susan Thompson suggests that surface velocities are not linear superpositions of separate eigenmodes. This result implies direct interaction and energy transfer between pulsation modes at the stellar surface.

7. Lopez-Morales, M., and Clemens, J. C., 2004**, The Pisgah Automated Survey: A Photometric Search for Low-Mass Detached Eclipsing Binaries and Other Variable Stars**, PASP, 116, 22-37.

My work on the cataclysmic variables highlighted the woeful state of the observational mass-radius relation for stars less massive than the sun. In 2004, measurements existed for only six stars. This problem persisted because measuring mass and radius together requires an eclipsing binary, and only three such systems below one solar mass had been discovered by accident. The PISGAH survey was a student-led project to systematically search for new low-mass eclipsing binaries using an automated digital camera. The poor weather at the site hampered the output of the survey, but the technology developed formed the basis for the PROMPT gamma–ray burst project. The student leading the project, Mercedes Lopez-Morales, added two new measurements to the mass-radius relation and launched herself into a Carnegie and Hubble Fellow.

8. Clemens, J. C., and Rosen, R., 2004, **Observations of Non-radial Oscillations in Radio Pulsars**, ApJ, 609, 340-353.

9. Clemens, J. C. and Rosen, R., 2007, **A Pulsational Model for the Orthogonal Polarization Modes in Radio Pulsars**, ApJ, 680, 664-670.

In the middle of the last decade, graduate student Rachel Rosen and I explored an alternative theory for the origin of drifting and stationary subpulses in radio pulsars. This work was motivated by the generally poor predictive value of the existing models, and the publication by Edwards, Stappers, and van Leeuwen of a subpulse phase jump evocative of observed pulsational behavior in rapidly oscillating Ap stars. We managed to construct an attractive and effective quantitative model based on non-radial oscillations. Rosen has applied our model to archival data and new observations made with the GBT facility in Green Bank, West Virginia.

10. Clemens, J. C., Crain, J. A., and Anderson, R., 2004, **The Goodman Spectrograph**, Proc. S.P.I.E., Ground-based Instrumentation for Astronomy, 5492, 331-340.

Alongside the research on pulsating white dwarfs, low-mass eclipsing binaries, and radio pulsars, I have constructed a facility-class spectrograph for the SOAR 4.1 m telescope. The Goodman Spectrograph is a $1.7M imaging spectrograph with extremely high ultraviolet throughput (45%). It incorporates volume phase holographic gratings, which we have learned to construct in the Goodman Laboratory. It is the workhorse spectrograph for the SOAR telescope, requested in 60-70% of observing time proposals.

The Goodman Spectrograph and the volume phase holographic grating production facility form the core of an ongoing instrumentation program that I use to train students in instrumentation and to produce a variety of smaller tools for astronomical research. With students, I have produced a time-series photometer for instructional use, a lucky imaging camera for testing at SOAR, a polarimeter for the PROMPT gamma-ray burst telescopes, optical designs for the PROMPT infrared camera, and a variety of other small instrumentation projects. This effort serves an often-neglected component of graduate student training.

11. Clemens, J. C., Evans, C. R., Taylor, R. M., and Gregory, D. M., **Reflector assemblies, systems, and methods for collecting solar radiation for photovoltaic electricity generation**, patent issued Jan, 2009

When Hurricane Katrina shocked US energy supplies in 2005, and destroyed a large fraction of my birthplace, I decided that I did not want to dedicate the rest of my professional life to astronomy alone. Together with 3 colleagues, I formed a company called MegaWatt Solar, Inc. Our mission was to develop and deploy utility-scale concentrated photovoltaic solar generators. We developed designs that reduce the cost of this technology to within striking distance of conventional electrical generation. In April, 2007, we received $17M in committed venture funding to commercialize our solution and bring it into production. Unfortunately, market forces brought the cost of flat panels, our main competition, to artificially low levels and the company had to be shelved.

12. Clemens, J.C., and O'Donoghue, D.E.A.A., **Curved volume phase holographic (vph) diffraction grating with tilted fringes and spectrographs using same,** pending, submitted June, 2012

The decision to take command of VPH technology in building the Goodman Spectrograph has recently paid off with our invention of a technique to construct spherically (or aspherically) curved VPH gratings. These gratings are capable of correcting the aberrations of a spherical mirror without any additional optics. In a reflection mode, they enable very elegant folded Offner spectrographs with only two elements. In transmission, they enable an entirely new class of instruments we are calling Spherical Transmission Gratings Spectrographs (STGS). These are elegant, compact, and efficient spectrographs that improve upon existing designs in many ways. We have received funding from the NSF to develop this technology for incorporation in future astronomical instruments. In a spinoff company, Syzygy Optics, we are also developing this technology for commercial hyperspectral imaging systems for use in the chemical, agricultural, forestry, and mining industries.

13. Barlow, B.N., Dunlap, B.H., Rosen, R., and Clemens, J.C., 2008, **Two New Variable Hot DQ Stars,** *ApJ (Letters)*, 688, L95-L98.

14. Dunlap, B. H., Barlow, B. N., and Clemens, J. C., 2010, **A New Small-amplitude Variable Hot DQ White Dwarf,** *ApJ Letters*, 720, L159-L163.

15. Dunlap, B. H., & Clemens, J. C. 2015, **Hot DQ White Dwarf Stars as Failed Type Ia Supernovae**, Astronomical Society of the Pacific Conference Series, Vol. 493. San Francisco: Astronomical Society of the Paific, 2015, p.547.

My graduate students Barlow and Dunlap discovered most of the members of a new class of variable white dwarfs called the hot DQ stars (DQV). Though they were initially thought to be pulsating stars, Bart Dunlap has built a strong case that they are magnetic rotators characterized by carbon dominated atmospheres, high masses, high temperatures, strong magnetic fields, and rapid rotation. Dunlap has further shown that while their high masses and temperatures imply a young cooling age, their kinematics are those of an older population. This age conflict is best resolved if they represent the reheated merger of two C/O white dwarfs that just failed to ignite as a supernova Ia, a hypothesis that deftly explains all of their other properties. As "failed SNe Ia" they offer a window into the space density of double degenerate mergers, and their interesting properties serve as a calibration points for numerical merger simulations. This month we will submit a paper to Nature on these results.

16. Dennihy

Teaching and mentoring statement

Mentoring

Mentoring starts not with a plan but with a philosophy. First, I see my graduate students as my scientific colleagues---not future colleagues, not potential colleagues, but colleagues in the fullest sense. However, unlike other colleagues, they have a priority in my time and attention, so that when they need something they get it more quickly. Second, I do not subscribe to the theory that the demands of graduate school should consume the lives of my students in order to prepare them for challenging careers "in the real world". On the contrary, graduate school is a real career phase, in which the habits of work and life begin to form, and if they cannot be brought into balance, a life of drudgery and misery will follow. I want my students to be people with rich lives first and scientific careers second; if work and activity overtake the life of the mind then we are missing the point of our vocations to explore, study, learn, and teach.

This philosophy has helped me attract and successfully mentor a group of diverse and very successful scientists whose names are listed in section f of this CV. Of the seven who have completed graduate work under my supervision (7 PhD, 1 MS), two are faculty in astronomy programs, two work for observatories run by NASA or the national observatories, two work in industry, and one runs a complex logistical operation---a household with five children.

Teaching

Many undergraduate students not only do not yet know how to think well, they are not aware that thinking is allowed. I am less interested in teaching astronomy than I am in teaching students that it is acceptable, even profitable, to think and reason for themselves. Astronomy is an excellent vehicle for this, if it is presented using broad strokes. In introductory classes, I do not teach facts and figures, but models and reasoning. I insist that students participate in this exercise, even in large classes, and I give them occasional pop-quizzes to make sure they are mentally present. I make it dangerous for the students to remain passive. The feedback I receive indicates that this keeps the students engaged.

Of course, being engaged is not sufficient; the students also have to perform. I have found that students perform more-or-less according to the expectations we have for them. The challenge in introductory courses is to keep the expectations high. My exam questions in introductory astronomy are sufficiently difficult that I have used them on the PhD qualifying exam. None of my tests have multiple-choice questions, because I find it difficult to force the students to think, or to measure the depth of their thinking using that format.

Teaching a class this way requires a lot of effort and energy. I am regularly inundated during my office hours, and grading 3 long-answer tests and numerous quizzes each semester is agonizing. The reward is that some students begin to think and to question the things they know in a deeper way. They also discover a set of tools for making this process systematic. I have little illusion that they will remember minute details of astronomical knowledge ten years from now, but I know many of them will profit from being pushed hard to think and understand rather than to accept and remember.

For my graduate students, and upper-level undergraduates, the process is not too different, but the content offers new challenges. All of astronomy relies fundamentally upon measurement, but understanding the devices modern astronomers use is a weak or non-existent component of most training programs. I am trying to insure that our students here will have sufficient understanding of astronomical instruments to know how they distort and contaminate our measurements. This has required building new equipment, and developing courses for which there exists no adequate text. It has also required involving graduate students in the development of new instrumentation, which has been an arduous, but worthwhile challenge.

Exhibit 2 to Clemens Declaration

Ex 2

Exhibit 3 to Clemens Declaration